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The Thermal Grill Illusion: A Study Using a Consciousness System

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Abstract

Although the thermal grill illusion has been the topic of previous research, many mysteries still remain regarding psychological determinants, neurophysiological mechanisms and so on. Also, the illusion cannot be simulated by information science and robotics. This study focuses on a very simple but interesting experiment called Hot and Cold Coils, which is known as a typical example of the thermal grill illusion. The authors aim to explain the thermal grill illusion by proposing a new and bold assumption called the conflict of concepts, and demonstrate how to construct a model by using an artificial consciousness module called the Module of Nerves for Advanced Dynamics (MoNAD). A simple experimental apparatus was prepared to prove the existence of the thermal grill illusion, and consists of a parallel arrangement of bars with an alternating pattern of cold and warmth at 20°C and 40°C. The authors conclude with the belief that many complex perceptions of humanity can be simulated through the use of neural networks, and that this can help us to deeply study the cognitive processes of human perception.

Keywords: Artificial consciousness, Cognition and behavior, Neural network, Robotics, Thermal Grill Illusion

1 Introduction

Consciousness has been researched in various disciplines such as psychology, philosophy and brain science. However, the ultimate question of "what is consciousness" is a mystery that is still unresolved. We considered a large number of research studies, and proposed this definition: *"the consistency of cognition and behavior is the origin of consciousness."* From this definition, various models such as those for human spirit, emotion and thought, can be constructed by combining consciousness modules developed by the authors which are called the Module of Nerves for Advanced Dynamics (MoNAD).

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The MoNAD modules use recursive neural networks (RNN) and can explain the phenomenon of human consciousness well.

Based on our definition of consciousness, we think that when humans learn a new concept, they often examine their memory for knowledge similar to the unknown concept and they integrate their existing knowledge to make up new concepts. However, when the new concepts are examined and integrated, various positive and negative information may collide within the brain. Therefore, this paper proposes this hypothesis: *"When humans learn a new concept, a conflict of concepts from various information sources may sometimes occur."*

In the process of this study, we found a very interesting experiment called Hot and Cold Coils. This experiment consists of copper coils arranged in three sections. One outer coil is cold to the touch and the other is hot. The center section is made up of alternating rings of cold and hot tubing. This cold and hot is just an innocuous sensation like cool and warm. When the outer section is touched it feels cool to the hand, and the outer section feels warm. However, when the center section is touched, the hand will feel painfully hot. This illusion is called the Thermal Grill Illusion or synthetic heat, and was first demonstrated in 1896 (Thunberg, 1896). Researchers still cannot clearly explain the prickly, burning sensation it creates.

In this paper, we construct an artificial consciousness as the foundation of the MoNAD (Takeno, 2005), and attempt to model various functions of the human brain. We conducted this study as an example of the Hot and Cold Coils phenomenon, and will use it to more deeply study methods of recognizing the various concepts of the human brain.

2 Conflict of Concepts

A conflict called the Oedipus complex is proposed in a famous study by Levin at Yale University. This conflict is resolved progressively, in which the infant will grow up when they are able to identify their themselves and their parents (Andreason, 2006). N.E. Miller addressed conflict with the concept of a goal gradient, and created an action-theoretic system of this conflict (Miller, 1944). Although these hypotheses have been completely clarified in learning theory and behavioral theory, there has also been some research by J.H. Masserman and Joseph Wolpe who take a position that considers that experimental neurosis is generated from the conflict situation. In addition, we also believe that external conflict is in a state of confusion or in a psychological chaos of the nervous system.

In our present study, we state our belief that concepts or knowledge circulate within human cognitive systems. Sometimes, the architectures of human knowledge are in competition. By using our MoNAD consciousness modules, we are able to explain this competition as the knowledge of cognition and behavior in human consciousness systems and to demonstrate that it is a consistent and circular system. And we also explain why the human mind can be so complicated and ambiguous. These phenomena not only occur in human sensations, they also occur in human emotions. We call this concept the Competition of Knowledge. In this paper, we will attempt to explain how it works in the thermal grill illusion.

3 The Conscious System

Our conscious system is based on MoNADs, the modules of artificial consciousness that are layered in the system. Each MoNAD is driven by a top-down and bottom-up hierarchical system to continually exchange information between the lower- and higher-layer MoNADs (Takeno, 2012). In this paper, we describe in detail the structure and flow of information through the neural networks in the conscious system. We created the conscious system shown in Figure 1 using three subsystems: Reason Subsystem, Emotion and Feelings Subsystem, and Association Subsystem. The Reason Subsystem performs recognition and behavior based on the surrounding circumstances, determines actions and represents this state. The Emotion and Feelings Subsystem is based on the internal environment and the external environment, it represents stimuli generated in the body and representations of emotion and information from other consciousness modules. The Association Subsystem has the role of compiling rational thinking and emotional thinking.

In this paper, we present two proposals of the conflict of concepts using our conscious system. These proposals represent two different cognitive structures of the human brain to explain how the conflict of concepts works in the thermal grill illusion.

First, we describe the function of each module. In Figure 1, Re and Be are MoNADs of the Reason Subsystem. Re outputs the rational behavior of the body using inputs from the external environment, and outputs a reason or behavior to Be as a monitor, and these may be movements such as stop, move back or move forward. Pa, P, UP, Se are MoNADs of the Emotion and Feelings Subsystem. In this study, the conscious system can output three types of behaviors. Pa represents how pain is felt when conflict or pain occurs, and in response the representation is pleasant or unpleasant. Se is a MoNAD that unifies temperature information into two patterns: hot or cold.

Although the functions of Re, Be, Se, Pa, P and UP in the model with unit A and unit B are substantially the same, in this study the most important part of this conscious system is the Unification MoNADs (Un MoNAD) in the emotion and feelings subsystem, which unifies information from the Se MoNADs. In principle, the structure is quite different between model A and B. However, the conflict of concepts occurs in that part of the Un MoNADs in both models A and B. According to our hypothesis, the concepts of both hot and cold will cause a conflict because they are exactly opposite concepts. The flow of information in this conscious system is driven by a top-down and bottom-up system to continually exchange information between the lower- and higher-layer MoNADs. In this conscious system, IP(TE) functions as an input for temperature, as a primary nervous system, and it is comprised of many sensors as a group which we call the Sensor Group.

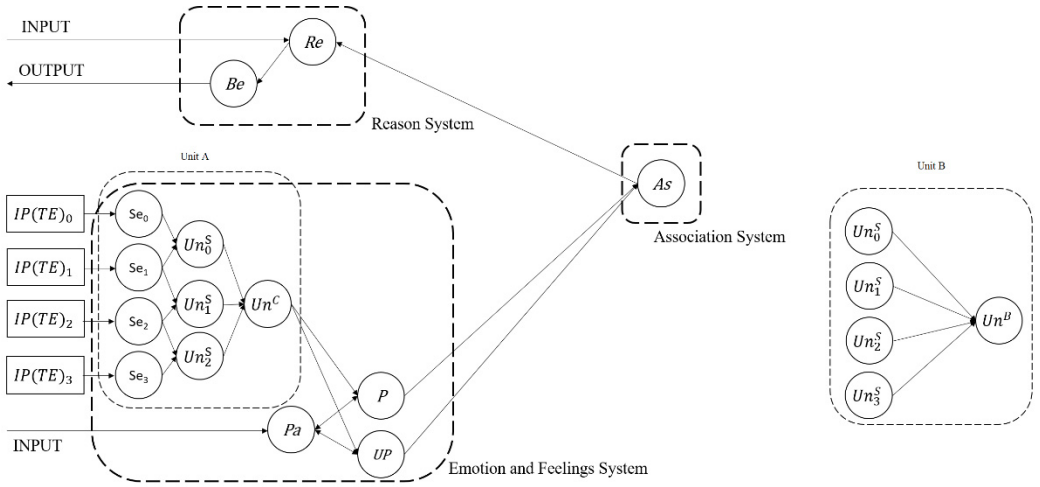

Figure 1: Detailed diagram of the conscious system model with unit A (left) and unit B (right)

Next we describe the difference between the model with unit A and unit B.

The unit A in Figure 1 on the left is our main object of study. With the unit A, we attempted to explain how the thermal grill illusion works with a brain mapping of the Homunculus. In this model, we think that information with the conflict of concepts must be confirmed by the somatosensory system, and processed in the insular cortex and cingulate cortex (Lindstedt, 2011). The reason is that the conflict of concepts of the thermal grill illusion occurs in the same hand instead of in the different hands, or sensors. In the unit A, the Se MoNADs will receive information from IP(TE) as inputs like temperature and location. Thereafter, all of that information will be unified by the Un^s MoNADs as a result or explanation such as hot, cold or conflict. Then, all the information processed by the Un^s MoNADs will be unified by the Un^c MoNAD once again as a result of hot, cold or conflict. This system in which the information is unified and explained as in the unit A, we call the Multiple Interpretation System of the MoNAD.

The unit B on the right in Figure 1 is the model that we are still studying. We built this model because we learned of a function magnetic resonance imaging (fMRI) study of the thermal grill illusion (Craig, 1994, 1996). The anterior cingulate and insular cortex are activated only in human subjects in connection with an intense burning sensation following hand contact with the thermal grill. Because the brain has the highest processing permissions, and pain has the highest priority, we thought that the brain may skip the location information from the somatosensory system because it already knows where the source sensors are. Also, with respect to the Multiple Interpretation System of MoNAD, for this unit B we call it the Single Interpretation System of the MoNAD or the Brain Interpretation System of the MoNAD.

4 Simulations

4.1 Overview of Simulations

We performed simulations using the conscious system with the unit A as described above in Figure 1. The intent of the simulations was to verify the existence of the conflict of concepts and describe how it works in the thermal grill illusion.

In this paper, we have built a conscious system with eight sensor inputs and one pain input. These eight sensors are just like four pairs of nerve cells, and they can be activated by external stimuli when they feel hot or cold. The eight sensors represent eight sensors or sensor groups in one palm. The pain input is an initial state that represents extreme feelings such as overheating pain or overcooling pain. For the convenience of illustration, we defined no extreme feelings in the simulation in this paper. The outputs of the simulation are conflict occurring or no occurring, sensation pain or not, pleasant or unpleasant feelings, and robot (conscious system) behaviors. In the simulation, we built this conscious system instead of a robot. At first, the robot (conscious system) will stop when there are no external stimuli inputs. The robot (conscious system) will also stop when it feels no pain or feels pleasant. When a conflict occurs or pain and unpleasant feelings are represented, the robot (conscious system) will move back.

We have prepared three kinds of simulations to describe how the conflict of concepts works.

4.2 Simulation of Separate Sensors Activated

4.2.1 Single Sensor Groups Activated

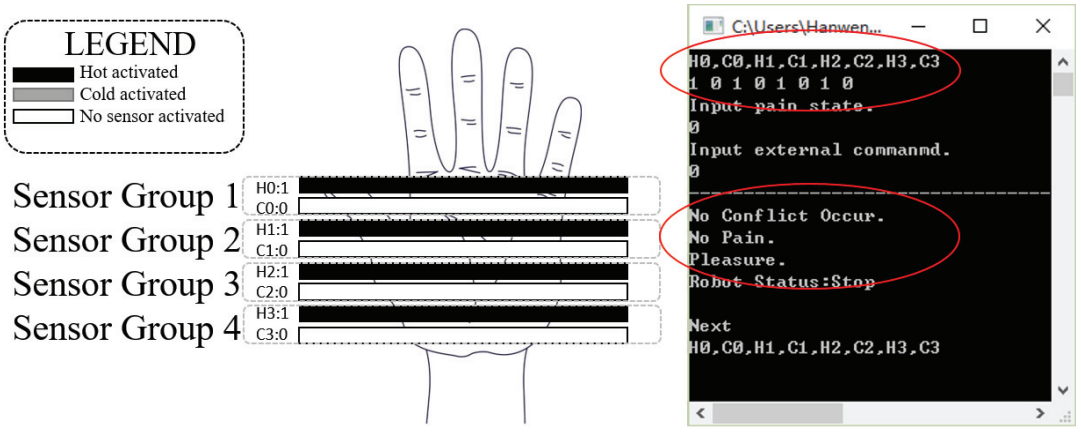

Figure 4: Simulation of hot sensors activated

In the simulation shown in Figure 4, all Sensor Groups have been activated by hot stimuli. At this time, the Un^s MoNADs at the first interpretation system will confirm that all Sensor Groups are hot. And the Un^c MoNAD at the second interpretation system will also unify all information from the Un^s MoNADs as hot. Conflict will not occur because there are no opposite concepts involved. As a result, the robot (conscious system) will stop because it feels no pain and it feels pleasant.

4.2.2 Conventional Model of the Thermal Grill Illusion

In the simulation shown in Figure 5, sensor H0 in Sensor Group 1 and sensor H2 in Sensor Group 3 have been activated to represent the status of Sensor Group 1 and 3 as hot. With respect to these sensor groups, sensor C1 in Sensor Group 2 and sensor C3 in Sensor Group 4 have been activated to represent the status of Sensor Group 2 and 4 as cold. In this simulation, the Un^s MoNADs at the first interpretation system will confirm each Sensor Group to be a single state of hot or cold. At this time, a conflict will occur in the robot (conscious system) and the resulting behavior will be to move back.

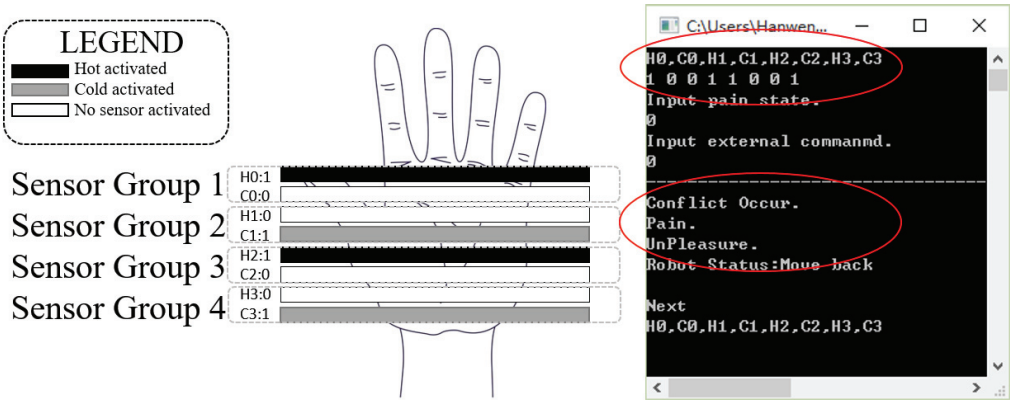

Figure 5: Conventional model of the thermal grill illusion

4.3 Simulation of All Sensors Activated

In the simulation shown in Figure 2, all sensors are activated when they feel both hot and cold. According to our hypothesis, this will obviously cause a conflict because hot and cold are exactly opposite concepts. In the unit A, all information from sources have already been unified to conflict by the Un^s MoNADs at the first interpretation system. And this information is input as conflict information to the second interpretation system by the Un^c MoNAD. Also, these information inputs will be unified to conflict, too. This represents that the conflict of concepts has occurred. The robot (conscious system) will move back.

And, conversely, when no sensors are activated, the robot (conscious system) will stop, which is a normal state.

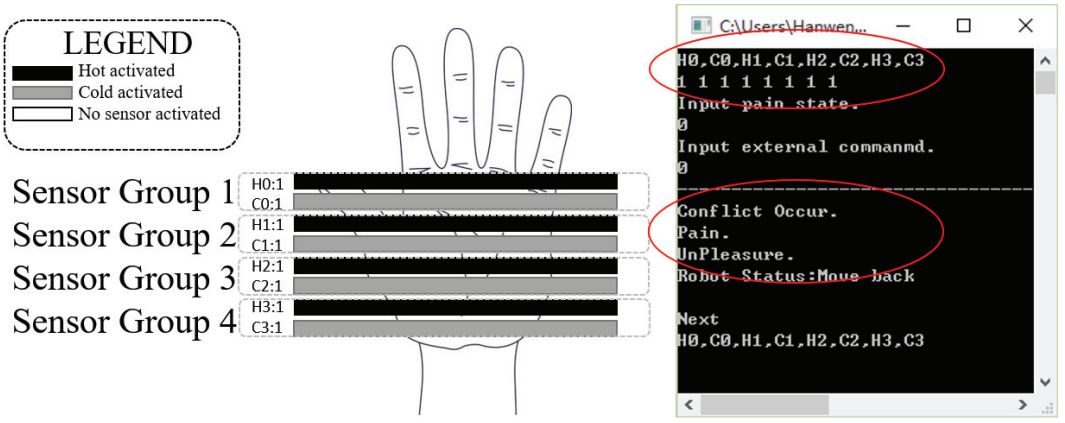

Figure 2: Simulation of all sensors activated

4.4 Summary of Simulations

These simulation results demonstrated that the conflict of concepts is capable of being used to explain the thermal grill illusion. These simulations demonstrated that the Multiple Interpretation System of the MoNAD can accurately perform cognitive judgments of the external environment and external stimuli. However, how to simulate the unit B and how the Single Interpretation System of the MoNAD works are issues that we will address in the future.

5 Conclusion and Observations

Although many studies have been conducted about neural networks and sensors, sensor-brain models are still few in number, such as those that might address the reason for the thermal grill illusion. We believe our hypothesis of the conflict of concepts is not only capable of being used to explain the thermal grill illusion, it also can explain many illusions in the human cognition process. Furthermore, our hypothesis may also prove to be a valuable tool for building an interesting model for explaining human cognitive psychology.

In the process of this study, we considered the conflict of concepts to be knowledge that would be gradually improved in the evolutionary process. Therefore, related to the hypothesis of genetic memory or racial memory of Carl Jung (Llinas, 2001), we discussed whether a conflict of concepts could be hereditary in memory as knowledge.

As an important objective in the future, we will attempt to explain how the conflict of concepts works in the high-level cognition of humans such as in many advanced illusions. In the conscious system with unit A, we believe that conflict occurred in the second interpretation system at the Un^c MoNAD because information from the Un^s MoNADs can be unified repeatedly into an exactly opposite concept, and the brain can determine the type to conflict or other status finally. And we will also attempt to simulate the conscious system using the unit B on a robot. However, our hypothesis of the conflict of concepts is still not adequately developed. Therefore, we will continue studying it and exploring more valuable evidence to prove its existence in the future.

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